

forward, particularly since it is likely that all five proposed non-GSO systems will not be built. AMSC's use of the newly-allocated MSS bands will have little if any adverse impact on the plans of the non-GSO system applicants.^{23/} AMSC has demonstrated its commitment to sharing by its active and cooperative work on the Negotiated Rulemaking Committee. Moreover, a regional GSO system is far more benign from a spectrum management perspective than another global non-GSO system would be.

In sum, AMSC has a clear need for the additional spectrum and can use it more quickly, more efficiently, more cheaply, and more flexibly than any of the non-geostationary system proponents. Moreover, AMSC can do so without affecting the plans of the non-geostationary MSS applicants.

B. Geostationary MSS Systems Have Substantial Advantages Relative to Non-Geostationary Systems

The Commission's proposal to license the newly-allocated MSS bands only to non-GSO systems appears to be based on a belief that non-GSO technology has significant advantages over

^{23/} In the NPRM, the Commission cites as precedent an earlier satellite proceeding in which it had rejected a proposal by one of the applicants (Omninet), which sought to operate an FDMA system that would have limited opportunities for multiple entry and, instead, adopted a wide-band spread spectrum CDMA requirement that would accommodate more systems. See NPRM, 9 FCC Rcd at 1104 para. 19, citing RDSS Licensing Order, 104 F.C.C.2d 650 (1986), at paras. 14-19. In fact, it is difficult to square the Omnet case with the Commission's proposal here. If the principles of the Omnet decision were to govern here, the Commission would not carve out spectrum for MSC's FDMA system and reject AMSC's attempt to promote sharing by operating CDMA.

geostationary satellite technology particularly in meeting the world's needs for improved communications.^{24/} AMSC believes, however, that the Commission's assessment of non-GSO MSS systems is greatly overstated. AMSC expects to be a major part of bringing Mobile Satellite Service to the world, through the development of technology and marketing experience and the establishment of a solid business, and perhaps in the long-term through participating in the provision of service in other regions. AMSC is convinced, however, that the most efficient means of reaching this goal, both technically and financially, is by constructing GSO systems and allowing them to expand incrementally.

History and the experience of established satellite communications providers shows that geostationary satellites are at least as well-suited as non-GSO satellites to providing global service. The Fixed Satellite Service uses geostationary satellites to provide tremendous communications capability to many remote parts of the world. Inmarsat's geostationary system is doing the same thing, providing communications to transportable mobile terminals no bigger than a large briefcase.^{25/}

^{24/} As the NPRM acknowledges, the Commission historically has had an aversion to picking technological winners and losers. NPRM, 9 FCC Rcd at 1100 para. 11. AMSC respectfully suggests that here as in past cases, the Commission should permit the market to determine which technology -- GSO or non-GSO -- is superior.

^{25/} At one point in the NPRM, the Commission cites the Fixed Satellite industry as precedent for the economic growth and U.S. technology leadership that it hopes will be stimulated (continued...)

There are good reasons for the success of geostationary satellite systems. As an initial matter, geostationary satellites are better than non-GSO satellites from a technical perspective. Geostationary technology is a proven technology that better permits satellite power to be directed to areas with the greatest traffic. The record in this proceeding substantiates this. In particular, Hughes Aircraft Company, the world's leading manufacturer of satellites, filed comments in this proceeding demonstrating that a global MSS system using as few as three GSO satellites can meet the Commission's global coverage requirements^{26/} and do so far more efficiently than a global system using non-geostationary satellites.^{27/} A primary reason cited by Hughes is that a geostationary system is able to focus its satellite beams on the most populated areas of the Earth -- therefore providing near-total coverage of the Earth's

^{25/}(...continued)

and maintained by non-GSO systems. This recognition of the Fixed Satellite industry, however, is inconsistent with the Commission's proposal to exclude the technology of the Fixed Satellite industry -- geostationary satellites -- from the use of the new MSS bands. See NPRM, 9 FCC Rcd at 1097 para. 4.

^{26/} With the exception of northern areas of Alaska, AMSC's GSO system will have no trouble meeting the Commission's requirement of coverage of all 50 States.

^{27/} See Comments of Hughes Aircraft Company, File Nos. 9-DSS-P-91(87) et al. (June 3, 1991), at 6-7. Attached hereto as Exhibit B is a further analysis of this issue by Hughes personnel, "Economic and Technical Considerations of a GSO Global MSS," Dr. George Hrycenko et al., delivered at the Pacific Telecommunications Conference, January 12-15, 1992 (the "Hrycenko Study").

population much more spectrum-efficiently.^{28/} In contrast, a non-geostationary system involves numerous satellite beams roving randomly over both populated and unpopulated areas of the Earth, thus much of the time merely wasting spectrum resources and satellite power.^{29/}

GSO systems also have a clear technical advantage over non-GSO systems in their ability to provide dispatch service over a large area. The user of a GSO system can reach any mobile terminal located on an entire continent by sending a signal through a single satellite, whereas the user of a non-GSO system would have to use several satellites to provide the same coverage. This wide-area dispatch service is particularly important for the transportation industry. Long-haul trucking companies, airlines and the federal government, for example, are increasingly using mobile communications including satellite technology to improve their efficiency, reduce fuel consumption, and improve the efficiency of their customers.

Another major advantage of geostationary satellites is that they are more economical. Again, the fact that technology

^{28/} The Hrycenko study found that a global GSO system with spot beams would have as much as twice the number of channels as a non-GSO system, in part because of the non-GSO systems' redundant ocean coverage and polar beam overlap.

^{29/} Although MSS provides service to mobile units, it is fairly obvious that many huge areas of the world (such as the oceans and deserts) have so little population that traffic through these areas will never be as heavy as it is in other areas with more people and activity. The Hrycenko study found that less than 0.5% of the world's population is excluded from geosynchronous coverage. The study also found that only about 5% of the addressable market for MSS exists over oceans, even though those areas cover most of the globe and absorb most of the energy of a non-GSO system.

development is incremental is particularly beneficial, since it reduces risk and makes it easier to project costs and raise capital. The non-GSO applicants claim to have estimated the costs of their systems, but until they begin to construct them, their estimates must be considered largely speculative. In addition, all of the estimates provide in the non-GSO system applications ignore the financial implications of the short useful life of non-GSO satellites. This greatly adds to the cost of the systems. Thus, for example, MSCI not only has to spend over \$3 billion to construct its system before it collects any revenue, but it then must spend another similar amount in the first 3.5 years of operation in order to replace its initial set of satellites.

The use of geostationary satellites also permits the more orderly development of the market, thus reducing the financial risk. Fixed Satellite Service developed first in high-traffic areas such as the U.S. and for trans-Atlantic communications, and then spread (rather quickly) to lower density areas. The same can be expected of Mobile Satellite Service. More specifically, VSAT technology and transportable satellite broadcast facilities all developed first in the U.S., but have rapidly been exported to Europe and Asia and the rest of the world.

Inmarsat is an entity that is unquestionably qualified to speak on the topic of global communications satellite systems. Many of the benefits of global service that the NPRM discusses are already being provided by Inmarsat, which has built a global satellite system incrementally, starting with lower-powered

satellites to serve large dishes on ocean-going ships and expanding its mandate and capability to serve smaller antennas on boats, aircraft and land-based vehicles -- all using geostationary satellites. Inmarsat is now developing its third generation geostationary MSS constellations. Significantly, Inmarsat has recently announced that it has ruled out low-Earth orbit satellites for Project 21, its global MSS system.

According to Inmarsat:

The LEO system exhibits the most difficulty in high blockage areas such as high rise locations. Call drop-outs would be frequent. . . . Though signal delays may be longer with the GEO system, once a link is established, it will not drop out if the user remains stationary.

The LEO configuration was dropped for reasons of cost, the results of the market research, and the relative complexities and risks associated with the production, implementation and on-orbit management of a large number of satellites.^{30/}

The issue of service to handhelds is another area of common misperception of the difference between GSO and non-GSO technology. In fact, high-power GSO systems can provide service to handheld mobile terminals. The quality of service to handheld units, however, is likely to be quite poor -- regardless of whether the system is a GSO or non-GSO -- because of the difficulty of penetrating buildings. As discussed below and in the attached Technical Appendix, even the best of the non-GSO systems will provide very poor communications inside a building. Therefore, AMSC has made the market judgment that the public will

30/ Elizabeth Hess, "Project 21: LEO, MEO or GEO?", Satellite Communications (October 1993), at 42, 46.

prefer higher-quality service with a vehicle-mounted, higher-power mobile unit.

The NPRM also appears to have a vision of non-GSO systems providing far more communications capacity than is at all practical to expect. At one point the NPRM claims that non-GSO MSS systems may provide an "'instant' global telecommunications infrastructure at minimal cost" that "can be used to provide both basic and emergency communications to . . . entire populations." NPRM, 9 FCC Rcd at 1096 para. 2. The reality is that no MSS system, with the amount of spectrum available currently, will have enough capacity to provide basic communications to entire populations.^{31/} Moreover, in most parts of the world even emergency services providers will not be able to afford the equipment and usage charges that will be associated with MSS systems that have such huge initial capital costs as characterize the non-GSO proposals before the Commission.

There is also no reason to expect non-GSO systems to bring any more benefits to the U.S. economy than would GSO systems. The NPRM concedes that the development of non-GSO systems, with their dependence on foreign authorizations, are likely to need substantial foreign investment. So far, the non-GSO applicants appear to be heeding this prescription, garnering much of their support from overseas. In addition, the European Community's DG-13 Committee has targeted non-GSO systems to make sure that

^{31/} The Hrycenko Study, for example, estimates that a global GSO system would have an effective capacity of 81,810 channels and a high-capacity non-GSO system would have 50,900 channels.

European manufacturers and service providers have a large share of any new business.^{32/} By contrast, the U.S. is a well-recognized leader in the development of geostationary satellites, and the use of geostationary satellites to provide MSS, domestically and internationally, will provide immediate and long-term benefits to the U.S. and global economies.

The NPRM suggests that non-geostationary satellites are particularly worthy as a "new technology." In fact, however, non-GSO satellites are not new. While they have not been deployed widely for commercial uses, for decades non-GSO satellite systems have been employed by governmental entities for military and scientific purposes. COSPAS/SARSAT, a three-satellite commercial low-Earth orbit MSS system for position location and distress communications, has been operating for over ten years. Indeed, in determining that none of the present non-geostationary MSS applicants are entitled to a pioneer's preference, the Commission itself has recognized that none of the proposed systems involve an innovative development in communications technology. Notice of Proposed Rule Making and Tentative Decision, ET Docket No. 92-38, 7 FCC Rcd 6414, 6419-22 paras. 33-51 (1992). Moreover, as noted above, the development of AMSC's own geostationary satellite system has been characterized by extensive innovation and advances in the state-of-the-art for satellite and ground system design.

^{32/} "KPMG Study Calls for EC to Get Organized for Global MSS," Mobile Satellite News (April 13, 1994), pp. 1-3.

The NPRM also suggests that non-geostationary MSS systems will have less time-delay in communications than will geostationary systems. NPRM, 9 FCC Rcd at 1105 para. 20. AMSC has shown previously, however, that MSC I's proposed non-geostationary system will have even greater time delays than a geostationary system on many of its communications links. AMSC Petition, Technical Appendix, at 63-64. Moreover, the attached Technical Appendix shows that not only will the proposed non-GSO systems experience more delay than a GSO system in setting up calls, but any edge the non-GSO systems might have in terms of reduced delay over the satellite path are insignificant.

C. The Proposed Non-GSO Systems Remain
Highly Speculative

While AMSC supports the Commission's desire to encourage the communications services that the non-GSO MSS applicants state that they will provide, and while AMSC has never sought to impede the non-GSO system proponents from going forward, the fact remains that the non-GSO system applications before the Commission present proposals that remain extremely speculative. As things stand right now, it is very questionable whether the non-GSO MSS applicants will be able to meet the standards the Commission itself proposes for use of the newly-allocated bands. Even if these applicants are ultimately able to meet the Commission's licensing standards, the many major inter-service sharing issues present serious obstacles to these systems' implementation. Under these circumstances, it is only prudent

for the Commission to permit AMSC and its regional GSO proposal to remain eligible to access the 1.6/2.4 GHz bands.

1. The Proposed Non-GSO Systems Are Unlikely to Comply With the Commission's Proposed Technical Standards

The Commission seems to envision a world in which mobile communication users can communicate anywhere in the world using handheld receivers while in cars, buildings, or anywhere else. The NPRM states that among "the almost limitless applications" of non-GSO MSS systems are "cellular-like mobile services to users anywhere." The Commission also proposes that all systems in the newly-allocated MSS bands provide coverage at least 18 hours per day at latitudes less than 80 degrees and continuous coverage of all 50 states.

The proposed non-GSO MSS systems are unlikely to meet the Commission's standards. For one thing, as shown in the attached Technical Appendix, these systems will not be able to provide reliable service to users in buildings, in vehicles or in urban areas. Thus, the international business travellers who are supposed to comprise a large share of the market for non-GSO system services will find that service is not available when they are in an airport, on a plane, in a taxi, in a hotel room or restaurant, or in an office building. This is not "continuous coverage."

Moreover, as AMSC has shown, several of the proposed non-geostationary MSS systems will have serious reliability problems. For example, the Constellation, Ellipsat, LQSS and MSC1 systems

will have frequent and prolonged outages. This is largely because of the low elevation angles of these systems' satellites and the constant motion of the satellites relative to the user. Callers may have an adequate signal path at the start of their communication, but as the satellite with which the user is connected moves across the sky and is shadowed by an obstacle, the call may fade or be lost. Moreover, a number of the proposed non-GSO systems will have extremely poor coverage of the Earth.^{33/} The attached Technical Appendix discusses these reliability problems further. Given these problems, it appears that the proposed non-GSO systems will not be able to meet the continuous coverage standard that the Commission proposes.

Another technical issue surrounding the proposed non-GSO systems is the risk of collisions with other objects in space. This risk affects not only the reliability of the proposed non-GSO MSS systems, but also poses a danger to a number of critical satellites operating in the same or lower orbital spheres. AMSC has shown that this concern is much more than the work of science fiction writers, particularly given the large number of satellites involved in each of the proposed non-GSO systems. The

^{33/} See AMSC Petition, Technical Appendix, at 46-49; December 1991 Petition at 11-12 & Technical Appendix at 5-10. TRW's system appears to have fewer apparent reliability problems, largely because of its proposed medium-Earth orbit. TRW, however, like the other non-geostationary system applicants, has provided insufficient information to determine its system's reliability in numerous areas of concern, including the sufficiency of its system's electrical power station, handover problems as a result of gateway earth station deployment, service restoration plans, and coverage gaps and self-interference problems as a result of spacecraft antenna pointing.

probability of collision with other orbiting objects is hundreds of times greater for low-Earth orbit satellites than for GSO satellites. Technical Appendix, Section II E. The Commission, however, has not addressed the issue of space debris.

2. The Non-GSO System Applicants Have Not Shown the Financial Ability to Construct and Operate Their Proposed Systems

The NPRM proposes strict financial standards for MSS applicants in the newly-allocated bands, in order to ensure that valuable orbit spectrum is not wasted on applicants that do not have or cannot find the financing to build their systems. NPRM, 9 FCC Rcd at 1107 para. 26. LQSS, MSCI, and TRW each have suggested in their applications that the internal resources of their parent corporations will adequately meet their financing requirements.^{34/} None of the parent corporations, however, have indicated that they truly stand behind the financing of their proposed systems, but rather intend to rely on others for the financing of their systems and none have documented the availability and commitment of these other funds.^{35/}

^{34/} Application of LQSS, File Nos. 19-DSS-P-91(48), CSS-91-014 (June 3, 1991), at 69-70; Application of MSCI, File Nos. 9-DSS-P-91(87), CSS-91-010 (December 3, 1990), at 115; Application of TRW, File Nos. 20-DSS-P-91(12), CSS-91-015 (May 31, 1991), at 69-70.

^{35/} Based on MSCI's filings with the Commission, at most less than one-fourth of MSCI's estimated costs has been committed so far. "Motorola Completes \$800 Million Initial Round of Equity Financing for Global Iridium System," Telecommunications Reports (August 9, 1993), at 19. MSCI has provided to the Commission only a press release announcing this financing, which falls far short of the showing of commitment and ability the Commission proposes to (continued...)

Constellation and Ellipsat are start-up companies with no current assets, and present nothing more than "assurances" from financial and investment firms that sufficient financing "can be arranged."^{36/}

The recent difficulties experienced by Inmarsat in its attempt to obtain commitments from its signatories for Project 21 provide further proof that any global MSS system will be difficult to finance. If Inmarsat's members, with their deep pockets and direct knowledge of the global market, are reluctant to finance a new system, it is difficult to imagine others actually going forward.

35/(...continued)

require applicants for the new MSS spectrum to submit. See Letter of Veronica A. Haggart, Corporate Vice President and Director, Government Relations, Motorola, Inc. to Hon. James H. Quello, Chairman, FCC (August 2, 1993). Motorola's 1993 Annual Report indicates that its commitment to MSC1 is as a "strategic investment" in which it will invest less than 10% of the total cost and rely on others for the remainder, a process which the Annual Report concedes is not complete. Motorola, Inc. 1993 Annual Report at 23.

Similarly, LQSS recently announced the execution of a \$275 million equity financing, representing 15.27% of its total system cost. Again, the only details of this financing are in the form of a press release filed with the Commission. See Letter of William D. Wallace, Counsel to LQSS, to William F. Caton, Acting Secretary, FCC (March 24, 1994).

As to TRW, press reports indicate that it intends to propose a joint venture or lease agreement with Inmarsat to construct its proposed system. See "Iridium to Proceed with Final Round of Equity Financing," Communications Daily (April 22, 1994), at 3.

36/ Application of Constellation, File Nos. 17-DSS-P-91(48), CSS-91-013 (June 3, 1991), at 13; Application of Ellipsat, File No. 11-DSS-P-91(6) (November 2, 1990), at 35; Application of Ellipsat, File No. 18-DSS-P-91(18) (June 3, 1991), at 45.

By this analysis, AMSC does not mean to belittle the efforts of the non-GSO applicants. As discussed above, the capital costs of building a global system for an unestablished market are monumental, particularly when the satellites themselves typically have such short useful lives. AMSC also understands that none of the applicants have yet had an opportunity to submit a showing of their ability to meet the financing standards proposed in the NPRM. Nonetheless, the fact that the task is so daunting and that none of the non-GSO applicants appear ready to meet those standards should give the Commission cause to question whether the applicants are in fact financially prepared to construct their proposed systems and should cause the Commission to rethink its proposal to exclude AMSC and its relatively easily-financed system.

If the Commission does go forward with its proposal to exclude GSO applicants, AMSC urges it to strictly construe its financial standard to ensure that the spectrum is not "warehoused" by the non-GSO applicants. In addition, the Commission should clarify its requirements so that applicants must show an ability to finance not just the initial system, but also any replacement satellites that must be constructed and launched in the first few years of operation. As discussed above, non-GSO systems are not like broadcast facilities or GSO systems, inasmuch as non-GSO satellites typically have a very short useful life.

3. There Are Major Unresolved Issues Concerning the Availability of Sufficient Spectrum for the Proposed Non-Geostationary Systems

Even if the proposed non-GSO systems obtain Commission licenses, they will be faced with numerous inter-service sharing obstacles. The great majority of these problems are not impediments to AMSC, since AMSC's system will operate only in North America and since AMSC does not propose to operate in the portion of the 1.6 GHz uplink band utilized by RAS and aeronautical radionavigation. All of these problems, however, will impact upon the global systems proposed by the non-GSO applicants. There is little in the NPRM to assuage these concerns. The many inter-service sharing problems have been fully addressed by AMSC in prior filings, and as summarized below, virtually all of them remain unaddressed or unresolved in the NPRM.

Feeder Links: The NPRM all but concedes that none of the non-GSO MSS applicants will have access to the feeder link spectrum they seek.^{37/} Thus, all of the non-GSO applicants are faced with the need to find new feeder link spectrum and modify their proposals to incorporate new feeder link frequencies.^{38/} Further, the Commission addresses sharing of feeder link spectrum between GSO and non-GSO satellites by proposing only the most general of coordination obligations. The NRMC's findings indicate that coordination is an extremely uncertain solution.

^{37/} One of the non-GSO applicants already has appealed the Commission's refusal to allocate feeder link spectrum for the MSS applicants at issue. See Petition for Clarification and Partial Reconsideration filed by LQSS, ET Docket No. 92-28 (March 30, 1994), at 14.

^{38/} By contrast, AMSC, as a GSO system operator, should be able to use the 12/14 GHz bands that it has proposed for its system's feeder links.

2.4 GHz Downlink Band: There is no discussion in the NPRM of the likelihood of success in coordinating MSS operations in this band with fixed terrestrial stations in the U.S. and throughout the world. Domestically, the NPRM concedes that the record contains no views of affected terrestrial operators. An inadequate record also exists with respect to sharing between MSS and the ISM service, and in fact, one of the non-GSO applicants has stated that it may not be possible to provide MSS in densely populated areas because of ISM interference. The record is also inadequate concerning ITFS and MMDS operations in the adjacent 2500-2690 MHz band.

1.6 GHz Uplink Band: There is nothing in the NPRM to indicate that the Commission has considered the extent to which MSS operations in this band can be coordinated with the numerous countries in Europe, Asia and Africa -- including the former Soviet Union -- where fixed facilities operate on a primary basis in the band.^{39/} Moreover, protection of RAS operations in this band will require significant expenditures by the proposed non-GSO systems to implement position location capability in their mobile terminals, and will effectively preclude aeronautical MSS service in North America by these systems.

The attached Technical Appendix demonstrates that inter-service sharing problems for the non-GSO applicants have only intensified with time. Among other things, the Technical Appendix shows that whatever spectrum-efficiency advantages the non-GSO systems might have in the new MSS uplink and downlink bands are more than outweighed by those systems' need for vast amounts of feeder link spectrum that will be very difficult to access. All of these inter-service sharing issues raise serious questions as to whether the proposed non-GSO MSS systems will be able to access the spectrum they need to operate viably.


^{39/} Moreover, under RR 727 MSC1 must coordinate its secondary space-to-Earth operation in the 1.6 GHz band with some 29 additional countries in which terrestrial fixed stations operate on a secondary basis.

Conclusion

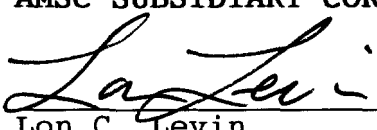
AMSC is not trying to convince the Commission to choose between GSO technology and non-GSO technology or between AMSC and the other applicants. AMSC believes that it has the better technology and the better business plan, but the Commission appears intent on permitting virtually all the cut-off applicants to go forward and letting the marketplace decide which, if any, will succeed. AMSC accepts that decision, but it rejects the Commission's proposal to exclude geostationary satellites from that marketplace opportunity. AMSC therefore urges the Commission to re-examine objectively the record in this proceeding; it believes that such a re-examination will lead the Commission to recognize the value of geostationary satellites, the need for AMSC's regional system to have access to additional spectrum, and the importance of insuring that this new MSS spectrum is actually put to use in the near future.

Respectfully submitted,

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TECHNICAL APPENDIX

TECHNICAL APPENDIX

INTRODUCTION

This Appendix addresses technical issues regarding the applications of AMSC Subsidiary Corporation ("AMSC"), Constellation Communications, Inc. ("Constellation"), Ellipsat Corporation ("Ellipsat"), Loral Qualcomm Satellite Services, Inc. ("LQSS"), Motorola Satellite Communications, Inc. ("MSCI"), and TRW Inc. ("TRW"), for authority to construct and operate Mobile Satellite Service ("MSS") systems to operate in the 1610-1626.5 MHz/2483.5-2500 MHz bands. Five of these applicants (Constellation, Ellipsat, Loral, MSCI, and TRW) propose satellites operating in non-geostationary orbit, and collectively will be referred to as the "NGSO Applicants." This Appendix is prepared in connection with the Commission's Notice of Proposed Rulemaking in CC Docket No. 92-166, which proposes licensing rules for MSS systems in the 1610-1626.5 MHz/2483.5-2500 MHz bands.

Section I of this Appendix addresses the ability of the proposed NGSO systems to provide service to handheld terminals. The NGSO Applicants have asserted that there is a substantial market for handheld MSS, but the proposed NGSO systems are incapable of addressing markets that are unique to handheld service such as buildings, vehicles and urban areas. This is because the high power margins needed for NGSO links to handheld terminals are either not available or if provided would substantially reduce system capacity below claimed levels. The NGSO CDMA Applicants (Constellation, Ellipsat, LQSS and TRW) at one time claimed that power control would enable the necessary power margins to be maintained without severe penalties on capacity, but such power control capabilities were shown to be unachievable under the "laws of physics" and in light of measured propagation characteristics.¹ The proposed TDMA system (MSCI) exhibits the capability for adequate power to serve handheld terminals in many areas, but there is low overall capacity for that service.

Section II of this Appendix shows that the claimed advantages of NGSO systems have been overstated and have not been weighed in light of the advantages of GSO systems. Among the claimed NGSO advantages is reduced time delay, which is not significant and may not exist in some cases. Moreover, as established by AMSC, the proposed NGSO

¹ The NGSO CDMA Applicants assumed during the NRMC that real-time, open loop power control could be used to minimize the power needed to compensate for signal propagation impairment. Later, in United States Working Party 8D during preparations for the November 1993 meeting at the ITU, this idealistic power control was shown to be impossible. Specifically, because the power transmitted at 1.6 GHz would be adjusted based on the power received at 2.4 GHz, and vice versa, and because propagation impairments at these widely separated frequencies are uncorrelated, the power control system would often reduce power when it needs to be increased.

systems have severe coverage difficulties. Furthermore, Section II shows that any potential high efficiency in NGSO service links is offset by inefficient NGSO feeder links. The fact is that six distinct types of orbits have been proposed, each of which has a number of unique performance and cost tradeoffs with respect to the others such that superiority of one type of orbit over another cannot be definitively established for all MSS applications.

Section III of this Appendix addresses the numerous inter-service sharing issues posed by the proposed NGSO MSS systems. These have been recognized by the FCC and are now the subject of study within several Study Groups in the Radiocommunications Sector of the International Telecommunication Union (ITU-R). As shown by AMSC in analyses presented in related proceedings, these problems will result in severe system design and operating constraints, reduce performance and increase the implementation costs of these systems. There are abundant feeder link interference problems in every band considered by the NGSO applicants that have prevented endorsement of any particular allocations and assimilation of the associated design and operating constraints and implementation costs. Moreover, the interference interactions for the planned service links in the 1610-1626.5/2483.5-2500 MHz bands are so onerous in certain geographic regions that service will not be possible, and the achievable performance and capacity in certain other areas will be poor. The solutions to these interference problems for service links will incur substantial additional costs and, where necessary, displacement of incumbents will take many years to execute.

I. NGSO SATELLITES CANNOT PROVIDE RELIABLE SERVICE TO USERS IN BUILDINGS, VEHICLES, OR URBAN AREAS

Based on comparisons of required and available link power margins, it is evident that none of the proposed NGSO systems will reliably serve handheld terminals located inside vehicles and buildings and in the many urban and suburban areas with nearby multi-storied buildings. Some of the proposed CDMA systems also will have difficulty serving handheld terminals even in areas devoid of nearby obstacles. The results of studies in the ITU-R indicate that margins of the order of at least 20 dB, 18 dB, and 12 dB are needed for effective NGSO service to handheld terminals located in buildings, urban/suburban areas and vehicles, and the more idyllic operating environments devoid of shadowing, respectively.² None of the NGSO Applicants propose to provide margins as high as 20 dB, although MSC1 appears capable of providing an 18 dB margin in trade for substantial capacity for service to vehicles or more favorably located handheld terminals. However, in the event that both the NGSO satellite and user are favorably located such that a call can be set up (e.g., in the outside room of an office with a window), the ensuing communications will be disrupted in

² See, e.g., CCIR Report to WARC-92, "Technical and Operational Bases for the World Administrative Radio Conference," Geneva (1991), Section 6.2.5; Document 8D/TEMP/63 (Rev. 2), "Impact of Propagation on the Design of LEO Mobile-Satellite Systems Providing Service to Handheld Equipment" (November 3, 1993).

most cases as the result of satellite movement to a less favorable position. The other NGSO Applicants do not provide even a 12 dB margin and can do so only with a substantial loss in capacity.³ Consequently, users expecting NGSO handheld units to perform as well as cellular handheld units will be disappointed.

II. THE MERITS OF NGSO MSS TECHNOLOGY HAVE BEEN OVERSTATED

A. Use of Low-Earth Orbit Altitude Does Not Necessarily Result in Less Time Delay

Delays in any of the four proposed low-Earth orbit ("LEO") systems and perhaps TRW's proposed intermediate circular orbit ("ICO") system are likely to be dominated by processing operations and may approach or exceed the delay in GSO systems. This is true of both technical access delay (i.e., time required to set up a connection during heavy system loading) and communications delay (i.e., time lag in message or audio delivery). As a result of protecting radio astronomy, technical access delay will be relatively high because of the requirement to know the location of a user requesting network access before access is granted -- it must be decided whether service can be provided at the user's location and, if so, on what frequency in relation to the radio astronomy band. This requirement necessitates incorporation of major additional processes in the network control system. In NGSO systems, this associated additional processing delay is accompanied by other operations that are not needed in GSO systems, which include processes for selection of and routing through the appropriate feeder link earth station and satellite. This is a significant handicap for NGSO systems, particularly for systems with relatively high capacity, insofar as technical access delay would be significant even without the requirement for frequency assignment by location. In addition, for users whose locations are not already known (e.g., persons who have just switched on their handheld unit), several seconds to minutes may be required for the position determination that must precede assignment of a channel. Thus, assuming comparable network control system technologies (e.g., computer-processor speed) and 100%-of-the-time coverage by NGSO systems, NGSO systems will have noticeably larger technical access delay than GSO systems.

Communications delay often is misunderstood to be the result of only signal propagation delays over the satellite radio path, which probably explains the misconception that NGSO satellites inherently have less communications delay than GSO satellites. On the basis of a conservative timing budget, AMSC showed that communications delays in Iridium could exceed those in a GSO system. Table 1 shows a conservative timing budget for a CDMA NGSO system using LEO satellites (ICO satellites would have even larger

³ LQSS has proposed the use of path diversity through two satellites in order to reduce the power margins needed to combat certain propagation impairments. However, LQSS has not provided sufficient information to enable evaluation of this technique.

propagation delay) without path diversity (which can introduce additional delay that stems from additional elastic buffering). The indicated delay is almost one-half that of GSO systems.

The most important interpretation of delay is that of the user, which is subjective. Communications delay over GSO channels is acceptable or unnoticeable by most users provided that echo is not noticeable; hence, ever since echo cancellation technologies matured, there has been widespread deployment and acceptance of GSO satellites for all forms of communications. No such track record exists for NGSO systems.

Table 1 - Estimate of Voice Communications Delay for CDMA Channels Without Path Diversity

SOURCE OF DELAY	AMOUNT OF DELAY
Mobile earth station CODEC processing and formatting (Note 1)	80 msec
Signal propagation to and from the satellite (Note 2)	10 msec
Feeder link earth station CODEC processing and formatting (Note 1)	75 msec
Buffer delay for beam-beam handoffs (Note 3)	0 msec
Buffer delay for feeder link handoffs (Note 4)	15 msec
Buffer delay for service link handoffs (Note 4)	15 msec
Overall Delay	195 msec
Notes: (1) Includes error control and interleaving (2) 3000 km combined length of up and down paths (3) Significant delay could occur to accommodate smooth handoffs of satellite service link (and feeder link) beams (<u>e.g.</u> , if there is a concomitant frequency change (4) Feeder and service link handoffs involve switching among feeder link earth stations and satellites, respectively, as a result of satellite movement	

B. GSO Systems Are More Spectrum-Efficient than the Proposed NGSO Systems

Spectrum utilization efficiency has been the subject of debate in the MSS Above 1 GHz Negotiated Rulemaking Committee ("NRMCM"). See NRC Report, Attachment 1, Section 8.1.4. Consideration of this issue in light of NGSO feeder link frequency sharing problems further attests that GSO MSS systems are more efficient. In principle, as the capacity of service links increases through frequency reuse enabled by increases in the number of antenna beams, the amount of spectrum required for feeder links also increases proportionally. That is, under the designs that have been put forward for both NGSO and GSO systems, any increased efficiency at service link frequencies appears to be counter-balanced by increased spectrum requirements at feeder link frequencies. Thus, an efficiency analysis must consider not only frequency reuse at service link frequencies, but also feeder link spectrum usage, particularly if one applies efficiency definitions based on the amount of spectrum denied to other systems. Specifically, for NGSO systems, increasing the frequency reuse at service link frequencies does not alter the amount of service link spectrum denied to other systems but does increase (proportionally) the amount of spectrum denied to other FSS systems. This is because NGSO feeder links cannot share frequencies with other FSS systems. In contrast, GSO systems can share feeder link frequencies with other FSS systems; thus, spectrum denied to other FSS systems is virtually independent of frequency reuse at service link frequencies. This efficiency advantage for GSO systems is particularly acute with respect to NGSO systems using intersatellite links, such as MSCIs. These links not only consume spectrum for a function that can be accomplished by other means, but also can increase the amount of spectrum needed for feeder links because the feeder links must accommodate both service link transmissions and intersatellite link transmissions. Consider, for example, a situation in which numerous persons in the United States are communicating through direct service link-feeder link connections and numerous service link users outside the United States are communicating through intersatellite links that connect into feeder links serving the United States. In such situations, the feeder link bandwidth requirements of NGSO systems could be as high as the sum of feeder link requirements for all satellites in the constellation.

C. The Proposed NGSO Systems Have Less Effective Coverage than a GSO System

As illustrated by AMSC in earlier filings, the NGSO systems as originally proposed will to varying degrees fail to provide full-time coverage.⁴ In contrast, because GSO satellites remain at a constant, high elevation angle, GSO systems have no trouble providing

4 See Technical Appendices to Response of AMSC, File Nos. 11- and 9-DSS-P-91, August 5, 1991, and AMSC Petition to Deny, File Nos. 17-/18-/19-/20-DSS-P-91, December 18, 1991.

full-time coverage to their service areas. Id.

D. Other Reliability Problems Are a Unique Concern for NGSO Systems

In addition to the NGSO reliability problems associated with coverage, AMSC has demonstrated that poor link availability and the absence of effective service restoration capabilities are manifest in the NGSO system proposals. See, e.g., Response of AMSC, File Nos. 11/9-DSS-P-91 (August 5, 1991), Technical Appendix, Section II.D. AMSC's system achieves good link availability for its proposed vehicular services by virtue of link power margins that are large in relation to the required margins. Instant restoration is enabled in AMSC's system through sparing, including an on-station satellite backup.

E. Orbit Debris Problems Have Not Been Resolved

The Department of Defense has established a collision prediction capability to eventually support the safe navigation of its NGSO satellites. See Janice Schultz, "Space Object Collision Prediction System Developed," Labstracts (1993), at 3. No such collision avoidance capabilities have been proposed or even recognized as being necessary by the NGSO MSS Applicants in the more than two years since AMSC revealed this problem. See, e.g., Petition of AMSC, RM-7806 (June 3, 1991), Technical Appendix, Section II. The density of debris in GSO systems is orders of magnitude lower than that in NGSO orbits, and so too is the probability of catastrophic collision.

III. THE PROPOSED NGSO SYSTEMS FACE SERIOUS INTER-SERVICE SHARING OBSTACLES

A. Frequency Selection, Design and Operating Constraints on NGSO Feeder Links

1. Problems Impeding Use of Fixed-Satellite Service Allocations

Because it was anticipated that there will be acute problems in accommodating feeder links for MSS systems using the new service link bands allocated by WARC-92, the ITU-R established Task Group 4/5 to conduct, define and study the feeder link problem and recommend solutions if possible. An analysis recently approved for submission by the U.S. to the June meeting of ITU-R Task Group 4/5 concludes that interference from NGSO systems to GSO systems operating in the fixed-satellite service ("FSS") exceeds permissible

levels.⁵ Thus, insofar as all FSS allocations are in use by conventional FSS systems at frequencies below 30 GHz, where rain fading may be at levels acceptable for NGSO MSS systems, the existing FSS allocations are unlikely to be usable for feeder links in NGSO MSS systems. The fact is that conventional FSS systems would have to accept a low quality of service in order to share frequencies with NGSO MSS feeder links operating in the same direction of transmission. The performance and associated protection criteria for conventional FSS systems, however, must be met in order for those systems to comply with end-to-end performance standards specified in Recommendations of the ITU Telecommunications Standards Sector; otherwise, the conventional FSS systems are unlikely to be commercially viable.

To make matters worse, some NGSO applicants apparently counted on either gaining acceptance of the interference their systems would generate in the 20/30 GHz FSS allocations that currently are lightly populated with conventional FSS systems, or by avoiding the frequencies used by those systems. However, the proposed Local Multipoint Distribution Service ("LMDS"), which is not compatible with NGSO MSS feeder links, may ultimately be assigned all available spectrum within the 30 GHz FSS uplink allocation. If this occurs, there will be no spectrum available for NGSO feeder links at 30 GHz. See Petition for Clarification and Partial Reconsideration filed by LQSS, ET Docket No. 92-28 (March 30, 1994).

2. Establishment of Other New Allocations

The NGSO Applicants stand no better chance of establishing new allocations for MSS feeder links than in gaining access to existing FSS bands. For one thing, FSS proponents have been seeking additional new allocations since before the 1979 WARC in order to accommodate demand, and there is no reason to believe that the NGSO Applicants will have any more success in obtaining new allocations. Moreover, the NGSO Applicants face an even greater challenge insofar as NGSO feeder links are less compatible with other services than are conventional FSS systems using GSO satellites. To put things further in perspective, spectrum requirements for NGSO feeder links that are being conveyed to Task Group 4/5 amount to several hundred megahertz of bandwidth per system, and could exceed a combined 1 GHz if NGSO advocates cannot find a way to share the same feeder link frequencies among themselves. In contrast, the success at WARC-92 of advocates of conventional FSS systems in obtaining just 250 MHz of new spectrum at 13.75-14 GHz was heralded as a major feat.

5 See Document USTG 4/5-2, "Analysis of Impact of Short Term Interference on FSS Services" (March 16, 1994). The analysis is based on a set of assumptions that were adopted at an earlier meeting of the Task Group. It is unlikely that this sharing situation can be shown to be feasible under any reasonable assumptions regarding system parameters and requirements.